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(71)Applicant : SONY CORP

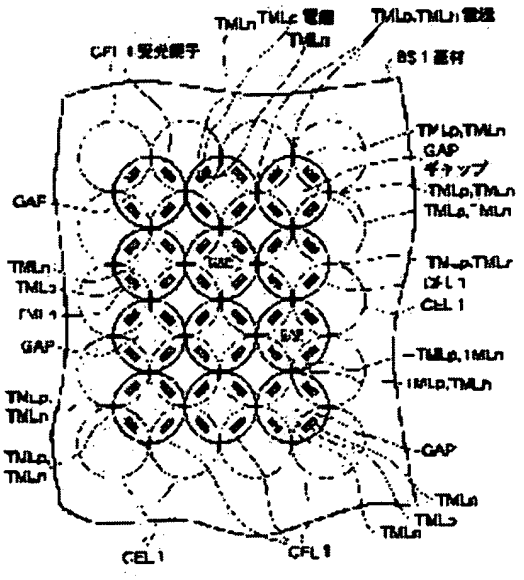
(72)Inventor : MATSUKUBO TAKASHI

(54) LIGHT-RECEIVING DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a light-receiving device for absorbing larger sunlight from a wider angle than that of a flat-plate type and for improving photoelectric conversion efficiency.

SOLUTION: A plurality of spherical photodetectors CEL 1 are arranged in a matrix, and are fixed to a nearly flat base BS1. In each of the adjacent photodetectors CEL 1, the N-type layers on each surface are connected by an electrode TMLn, and inside P-type layers are connected by an electrode TMLp. The matrix arrangement of the photodetectors CDL1 is in two layers, and the matrix arrangement (solid line) of the second layer is overlapped so that a gap GAP between four photodetector aggregates, for example, in the first-layer matrix arrangement (broken line). The first-layer and second-layer photodetectors that contact each other by overlapping are also connected by the electrodes TMLn and TMLp where a surface N-type layer and an internal P-type layer are provided.



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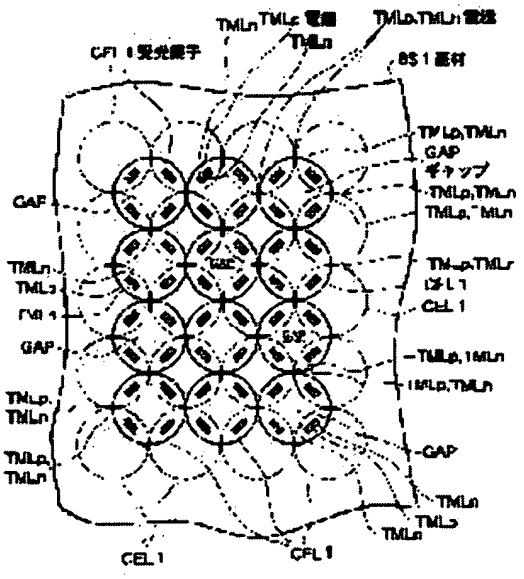

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CLAIMS

[Claim(s)]
[Claim 1] Light-receiving equipment characterized by providing the photo detector array object by which the photo detector of the spherule which has a PN junction is electrically connected to two or more [both], and the base material with which said photo detector array object is fixed.
[Claim 2] Said base material is light-receiving equipment according to claim 1 characterized by including a curved surface.
[Claim 3] Said base material is light-receiving equipment according to claim 1 characterized by having the electric conduction pattern electrically connected with said photo detector array object.
[Claim 4] Said photo detector array object is light-receiving equipment according to claim 1 characterized by being put and having electrical installation mutually.
[Claim 5] Light-receiving equipment characterized by providing the electric conduction pattern on the photo detector of the spherule which has a PN junction, the base material which two or more arrays are carried out and is fixed so that said photo detector may adjoin mutually, and said base material electrically connected with said photo detector.
[Claim 6] Light-receiving equipment according to claim 5 with which said photo detector is characterized by having electrical installation in two or more [both].
[Claim 7] Said photo detector is light-receiving equipment according to claim 5 characterized by accumulating more than one and having electrical installation mutually.
[Claim 8] Said photo detector is light-receiving equipment according to claim 5 characterized by preparing the reflecting layer in the alternative field.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the light-receiving equipment applied to the solar battery with which the high rate of photo electric conversion is demanded especially.
[0002]
[Description of the Prior Art] Energy problems are important on a world-wide scale, and the request and expectation which use sunlight etc. effectively as an energy source just grow. Light-receiving equipments, such as a solar battery and a photodiode, are very useful in it. However, since the consistency of solar energy is low, the power expected for photoelectric conversion efficiency to be low and not to collect sunlight from a big area after all is not obtained.
[0003] Generally, conversion efficiency of a silicon solar cell is theoretically made into about 24%. The present condition is about about ten% of conversion efficiency in fact by whenever [light transmission /, such as reflection of the light of a light-receiving side, a case, and a protective coat,], and recombination of a carrier, the series resistance loss further related to connection, etc.
[0004] Drawing 13 is the type section Fig. showing the configuration of the conventional light-receiving equipments (solar battery etc.). Various ****** besides GaAs and InP explains the ingredient used as a substrate about Si (silicon) here. For example, a diffusion technique etc. is used for the front face of the P type layer 71 which becomes by the P type silicon substrate, and the N type layer 72 is formed. Furthermore, on the N type layer 72, the oxidation silicone film 73 grade is formed as an antireflection film. An electrode 74 is connected to the P type layer 71, and the electrode 75 is connected to the N type layer 72. Two electrodes 74 and 75 are connected with a load 76.
[0005] By the above-mentioned configuration, the light L irradiated by the PN junction generates free charge. That is, by the electric field of the depletion region of the PN-junction section, an electron flows into the N type layer 72, and an electron hole flows into the P type layer 71, respectively. Thereby, the P type layer 71 is just charged in negative, photoelectromotive force produces it in it, and the N type layer 72 can take out a current from two electrodes 74 and 75 for a load 76.
[0006] However, although not illustrated, the light R reflected on N type layer 72 front face, and before reaching a PN junction, light which does not contribute to generating of a current, such as light of the short wavelength which an electron and an electron hole recombine, and light of the long wavelength of only merely penetrating a PN junction, is also considerably.
[0007]
[Problem(s) to be Solved by the Invention] Thus, in the former, light-receiving equipment with a flat front face is common in spite of low photoelectric conversion efficiency. In order to most often receive sunlight with low energy density, the gestalt which receives sunlight at right angles to a front face is important. With a monotonous mold, the direction of incidence which can use light effectively is restricted in the semantics.
[0008] This invention is made in consideration of the above-mentioned situation, and the technical problem can absorb more sunlight from an include angle larger than a monotonous mold, and is to offer the light-receiving equipment which realizes an improvement of photoelectric conversion efficiency.
[0009]
[Means for Solving the Problem] The light-receiving equipment of this invention is characterized by providing the photo detector array object by which the photo detector of the spherule which has a PN junction is electrically connected to two or more [both], and the base material with which said photo detector array object is fixed.
[0010] According to this invention, the configuration in which that a light-receiving gross area increases

compared with a monotonous mold with constituting the photo detector array object which consists of a photo detector of two or more spherules also absorbs further reflection of the light which doubled and carried out incidence is realized.

[0011]

[Embodiment of the Invention] Drawing 1 is the external view showing the configuration of the light-receiving equipment concerning the 1st operation gestalt of this invention. the photo detector CEL1 of a spherule arranges in the shape of two or more matrices -- having -- abbreviation -- it is fixed to the flat base material BS 1. The internal P type layer is connected by Electrode TMLp mutually [each adjoining photo detector CEL1 / a surface N type layer is mutually connected by Electrode TMLn, and].

[0012] The matrix array of these photo detectors CEL1 is two-layer like illustration. The matrix array (continuous line) of a two-layer eye is repeated so that the gap GAP during four photo detector sets in the matrix array (broken line) of the 1st layer may be buried. When put, the surface N type layer and the internal P type layer are connected by the 1st layer and the electrodes TMLn and TMLp with which the photo detector of the two-layer eye which contacts was also prepared mutually, respectively. These whole photo detector array is protected by the translucency resin film which is not illustrated.

[0013] Drawing 2 is the sectional view of arbitration showing the example of a configuration for connection 1 unit of photo detector CEL1 in drawing 1 . A photo detector CEL1 is covered with an antireflection film 201, and the translucency metal layer 202 is formed in the bottom of it. As mentioned above, each electrode TMLp is connected with the P type layer 203 of each photo detector CEL1 interior, and each electrode TMLn is connected with the N type layer 204 on the front face of a photo detector, respectively. Each electrodes TMLp and TMLn separate the insulator layers 205, such as an antireflection film and same oxidation silicone film, respectively, and are insulated.

[0014] Only a part to connect with the photo detector which the unit of such electrodes TMLp and TMLn adjoins is prepared in the predetermined part. Namely, the unit configuration of the electrodes TMLp and TMLn of illustration also doubles the connection about the matrix array of a mutually different layer, is the highest per photo detector CEL1, and is 8 unit **********.

[0015] The manufacture process of the photo detector CEL1 of a spherule is performed as follows, for example. While making the polish recon ingredient of the shape of ball-like polish recon material or a thin line which doped impurities of P type, such as boron, impress, fuse and recrystallize an RF generator, it is made to fall in fall tubing which cooled the tube wall, and is made to re-solidify.

[0016] Or a desired height is formed in the silicon single crystal substrate which doped the impurity of P type. To a height, the beam for heating is irradiated and is fused. This builds a melting solid sphere with the big volume with surface tension in a height tip. The root serves as seed crystal and a melting solid sphere carries out recrystallization growth. After predetermined time progress, the root is separated by the laser beam and the melting solid sphere which became large is solidified under the minute gravity in fall tubing etc.

[0017] thus, it was able to do -- doping and a surface layer are mostly formed to the silicon ball front face of a single crystal. That is, the gaseous diffusion of the impurity of N type is carried out, and a PN junction is formed in the predetermined depth from a front face. Next, spatter formation of the translucency metal layer (202) is carried out. Then, antireflection films (201), such as silicon oxide film and titanic-acid-ized film, are covered. Next, the electrode (TMLp, TMLn) which carries out ohmic contact is separated and formed in the predetermined part on the front face of silicon by insulator layers (205), such as an oxidation silicone film, with the lithography technique using a multi-mirror etc., respectively (refer to drawing 2).

[0018] Soldering is applied in order to connect each of each other's electrodes TMLp and TMLn by adjoining photo detectors. The configurations of each of electrodes TMLp and TMLn are various idea ****. Projection electrodes, such as a solder bump, may be formed.

[0019] Drawing 3 is the general-view Fig. showing the configuration of a part of photo detector in the matrix array periphery of drawing 1 . In each photo detector CEL1 in a matrix array periphery, common connection of each electrode TMLp is made, it is connected with a terminal 11, common connection of each electrode TMLn is made, and it is connected with a terminal 12. For example, it is easy to constitute if the electric conduction pattern connected with terminals 11 and 12 is formed in the seating-rim wall surface of the above-mentioned base material BS 1.

[0020] While controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it according to the above-mentioned configuration, the configuration which can absorb reflection of a light-receiving side further can be performed. That is, as shown in drawing 3 , Light L is absorbed by PN layer from the light-receiving side of a spherule, while the light R in which the remainder was reflected repeats reflection, is absorbed by the light-receiving side and changed into the electrical signal. Thereby, a current can be taken out from the

both-ends children 11 and 12.
[0021] By the configuration of the above-mentioned 1st operation gestalt, a light-receiving gross area increases compared with the photo detector of a monotonous mold, and contributes to improvement in the rate of photo electric conversion. It is good also considering the alternative up front face of the photo detector in a lower layer matrix array as a reflecting layer. Moreover, a base material front face may be covered with the reflective film.
[0022] Drawing 4 is the external view showing the advantage of this invention. The array of the photo detector CEL of the spherule in the above-mentioned configuration has the advantage which can respond even if the shape of surface type of a base material BS includes the curved surface to some extent. Thus, a base material may assume all things including the curved surface which is not the circuit board, and can fix and use it with adhesives etc.
[0023] When the matrix array of the photo detector CEL1 shown in the above-mentioned 1st operation gestalt is constituted by the base material including a curved surface, there is concern to which connection of the photo detector between different matrix array layers becomes difficult. In this case, connection of the photo detector between different matrix array layers may be lost. If a path cord is combined as a device of matrix array each of the 1st layer and the 2nd layer, the same terminals 11 and 12 as above-mentioned drawing 3 will be constituted.
[0024] Moreover, although the above-mentioned 1st operation gestalt showed the configuration of a two-layer matrix array, the configuration of only one layer is also considered. According to it, only the part which connects Electrodes TMLp and TMLn with the adjoining photo detector CEL1 is prepared in a predetermined part. By this, the unit which constitutes the group of Electrodes TMLp and TMLn will call it four units per photo detector CEL1. The configuration which can control the reflection of light which carried out incidence also in such a matrix array of one layer, and can be absorbed can be attained, and contributes to improvement in the rate of photo electric conversion. At this time, if base material BS1 front face is covered with the reflective film, in addition, it is good.
[0025] Drawing 5 is the external view showing the configuration of the light-receiving equipment concerning the 2nd operation gestalt of this invention. the photo detector CEL2 of a spherule arranges in the shape of two or more matrices -- having -- abbreviation -- it is fixed to the flat base material BS 2. Concerning each adjoining photo detector CEL2, a surface N type layer is mutually connected by Electrode TMLn about the direction of X of a matrix array, and the internal P type layer is further connected by Electrode TMLp mutually about the direction of Y of a matrix array.
[0026] The matrix array of these photo detectors CEL2 is two-layer like illustration. The matrix array (continuous line) of a two-layer eye is repeated so that the gap GAP during four photo detector sets in the matrix array (broken line) of the 1st layer may be buried. The mutual photo detector CEL2 of the 1st layer and two-layer eye which contact when put has fixed with the transparent adhesives which are not illustrated.
[0027] In each photo detector CEL2 in the above-mentioned matrix array periphery, common connection of each electrode TMLp is made, it is connected with a terminal 21, common connection of each electrode TMLn is made, and it is connected with a terminal 22. For example, it is easy to constitute if the electric conduction pattern connected with terminals 21 and 22 is formed in the seating-rim wall surface of the above-mentioned base material BS 2.
[0028] Drawing 6 is the sectional view of arbitration showing the example of a configuration of one connection about the photo detector CEL2 in drawing 4 . As mentioned above, Electrode TMLp is connected with the P type layer 203 inside a photo detector, and Electrode TMLn is connected with the N type layer 204 on the front face of a photo detector. These electrodes TMLp and TMLn are formed in the predetermined part, in order to connect with the mutual electrode of the photo detector CEL2 which adjoins the predetermined one direction (the direction of X, or the direction of Y) of a matrix array. Since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL2 of a spherule is omitted. The same sign is given to the same part as said drawing 2 . In addition, the antireflection film formed on the translucency metal layer 202 here is carrying out the illustration abbreviation.
[0029] While controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it also by the configuration of the above-mentioned 2nd operation gestalt, the configuration which can absorb reflection of a light-receiving side further can be performed. It is good also considering the alternative up front face of the photo detector in a lower layer matrix array as a reflecting layer. Thereby, a light-receiving gross area increases compared with the photo detector of a monotonous mold, and contributes to improvement in the rate of photo electric conversion.
[0030] Moreover, there is an advantage which can respond the same with being shown in said drawing 4

even if the shape of surface type of a base material includes the curved surface to some extent. Moreover, although the array of the photo detector CEL2 of a spherule constituted the two-layer matrix array, the configuration of only one layer is also considered. The configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and contributes to improvement in the rate of photo electric conversion. At this time, if a base material front face is covered with the reflective film, in addition, it is good.

[0031] In addition, although the mutual photo detector CEL2 of the 1st layer and two-layer eye which contact with this 2nd operation gestalt when the 1st layer and the matrix array of a two-layer eye are able to be repeated showed the configuration fixed with transparent adhesives Like the 1st operation gestalt, the electrodes TMLp and TMLn prepared, respectively may connect, one one of the electrodes TMLp and TMLn are formed, and a surface N type layer and an internal P type layer may connect each other.

[0032] Drawing 7 is the external view showing the configuration of the light-receiving equipment concerning the 3rd operation gestalt of this invention. On the flat abbreviation base material BS 3 with which the electric conduction pattern was formed, the photo detector CEL3 of a spherule is arranged in the shape of two or more matrices, and is being fixed. A surface N type layer is mutually connected by Electrode TMLn, and, as for each photo detector which adjoins each other about a matrix array, common connection of the internal P type layer is made with Electrode TMLp at the electric conduction pattern on a base material BS 3 (plate PLT).

[0033] The matrix array of these photo detectors CEL3 is two-layer like illustration. The matrix array (continuous line) of a two-layer eye is repeated so that the gap GAP during four photo detector sets in the matrix array (broken line) of the 1st layer may be buried. The P type layer electrode TMLp of each photo detector CEL3 in the matrix array of a two-layer eye is connected common to the electric conduction pattern on a base material BS 3 like the matrix array of the 1st layer by an electrode pin, a wire, etc. through the above-mentioned gap GAP (here, not shown). The whole photo detector array is protected by the translucency resin film which is not illustrated.

[0034] Thus, the each P type layer electrode TMLp in all the photo detectors CEL3 is connected with a terminal 31 through the electric conduction pattern on a base material BS 3 (plate PLT), common connection of the N type layer electrode TMLn of each photo detector CEL3 in one layer and a two-layer matrix array periphery is made, and it is connected with a terminal 32. For example, it is easy to constitute if the electric conduction pattern connected with a terminal 32 is formed in the seating-rim wall surface of the above-mentioned base material BS 3. In addition, since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL2 of a spherule is omitted.

[0035] Drawing 8 is the sectional view of arbitration showing the example of a configuration of the connection about the photo detector CEL3 of drawing 7 . The same sign is given to the same part as said drawing 2 . In addition, the antireflection film formed on the translucency metal layer 202 here is carrying out the illustration abbreviation. As mentioned above, Electrode TMLp is connected with the P type layer 203 inside a photo detector, and Electrode TMLn is connected with the N type layer 204 on the front face of a photo detector. About each matrix array, it adjoins, and electrode TMLn(s) connection is made mutually and common connection of each electrode TMLp is made at the electric conduction pattern (PLT) on a base material BS 3.

[0036] The electric conduction pattern on a base material BS 3 is the conductive thin plate PLT which reflects light like copper, only a connection place is connected with the P type layer electrode TMLp of a photo detector CEL3, and coating of the others is carried out by the translucency resin film FLM. The electrode TMLp of each photo detector CEL3 in the matrix array of a two-layer eye and the electric conduction pattern on a base material BS 3 (plate PLT) are connected by the electrode pin EP.

[0037] While controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it also by the configuration of the above-mentioned 3rd operation gestalt, the configuration which can absorb reflection of a light-receiving side further can be performed. That is, light is absorbed by PN layer from the light-receiving side of a spherule, while the light in which the remainder was reflected also repeats reflection, is absorbed by the light-receiving side and changed into the electrical signal. Consequently, a light-receiving gross area increases compared with the photo detector of a monotonous mold, and contributes to improvement in the rate of photo electric conversion. It is good also considering the alternative up front face of the photo detector in a lower layer matrix array as a reflecting layer.

[0038] Moreover, there is an advantage which can respond the same with being shown in said drawing 3 even if the shape of surface type of a base material includes the curved surface to some extent. Moreover, although the array of the photo detector of a spherule constituted the two-layer matrix array, the configuration of only one layer is also considered. The configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and contributes

to improvement in the rate of photo electric conversion.
[0039] Drawing 9 is the external view showing the configuration of the light-receiving equipment concerning the 4th operation gestalt of this invention. two or more photo detectors CEL4 of a spherule are constructed alternately, and constitute a slanting array -- as -- abbreviation -- it is fixed to the flat base material BS 4. The internal P type layer is connected by Electrode TMLp like said 1st operation gestalt mutually [each adjacent photo detector CEL4 / a surface N type layer is mutually connected by Electrode TMLn, and]. Electrodes TMLp and TMLn can be constituted like said 1st operation gestalt. Here, the group (unit) of Electrodes TMLp and TMLn is the highest per photo detector CEL4, and is 6 unit **********.
[0040] In each photo detector CEL4 in the periphery of a slanting array configuration, common connection of each electrode TMLp is made, and common connection of each electrode TMLn is made. For example, it is easy to constitute if the electric conduction pattern of each common path cord is formed in the outer frame wall surface of a base material BS 4. The whole array configuration is protected by the translucency resin which is not illustrated. Since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL4 of a spherule is omitted.
[0041] Drawing 10 is the general-view Fig. showing the important section about the base material BS 4 of drawing 9 . The ****** seating rim touches the honeycomb structure of a base material BS 4 to the periphery of the slanting array configuration of each photo detector CEL4. The common path cord 401 of each electrode TMLp and the common path cord 402 of each electrode TMLn are formed in the wall surface of this seating rim. The common path cord 401 is connected with a terminal 41, and the common path cord 402 is connected with a terminal 42.
[0042] According to the configuration of the above-mentioned 4th operation gestalt, compared with said 1st operation gestalt, the array consistency per one layer of matrix arrays in the photo detector of a spherule can be raised. Although you may make it two-layer, the configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and a light-receiving gross area increases it compared with the photo detector of a monotonous mold. This contributes to improvement in the rate of photo electric conversion. If a base material front face is covered with the reflective film, in addition, it is good. In addition, there is an advantage which can respond even if the shape of surface type of a base material includes the curved surface to some extent also in the above-mentioned configuration.
[0043] Moreover, although illustration is not carried out, as an application as said 2nd operation gestalt explained, it is very good in the configuration which connects electrode TMLp(s) of a photo detector CEL4 to a certain predetermined array direction, and the configuration which connects electrode TMLn(s). Thereby, the total of Electrodes TMLp and TMLn decreases about the photo detector CEL4 per piece.
[0044] Drawing 11 is the external view showing the configuration of the light-receiving equipment concerning the 5th operation gestalt of this invention. On the flat abbreviation base material BS 5 with which the electric conduction pattern was formed, two or more photo detectors CEL5 of a spherule are constructed alternately, and it is fixed so that a slanting array may be constituted. Like said 3rd operation gestalt, a surface N type layer is mutually connected by Electrode TMLn, and, as for each adjacent photo detector CEL5, common connection of the internal P type layer is made with Electrode TMLp at the electric conduction pattern on a base material BS 5 (plate PLT). The whole array configuration is protected by the translucency resin which is not illustrated.
[0045] The electric conduction pattern on a base material BS 5 is a conductive thin plate (PLT) which reflects light like copper like said 3rd operation gestalt, only a connection place is connected with the P type layer electrode TMLp of each photo detector CEL5, and coating of the others is carried out by the translucency resin film FLM.
[0046] That is, the each P type layer electrode TMLp in all the photo detectors CEL5 is connected with the electric conduction pattern (plate PLT) of base material BS5 pars basilaris ossis occipitalis. Moreover, common connection of each electrode TMLn of each photo detector CEL5 in the periphery of a slanting array configuration is made. For example, it is easy to constitute if the electric conduction pattern of the common path cord of Electrode TMLn is formed in the seating-rim wall surface of the above-mentioned base material BS 5. In addition, since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL5 of a spherule is omitted.
[0047] Drawing 12 is the general-view Fig. showing the important section about the base material BS 5 of drawing 11 . The ****** seating rim touches the honeycomb structure of a base material BS 5 to the periphery of the slanting array configuration of each photo detector CEL5. The common path cord 502 of each electrode TMLn is formed in the wall surface of this seating rim. The plate PLT of base material BS5 base is connected with a terminal 51, and the common path cord 502 is connected with a terminal 52.
[0048] According to the configuration of the above-mentioned 5th operation gestalt, compared with said

3rd operation gestalt, the array consistency per one layer of matrix arrays in the photo detector of a spherule can be raised. Although you may make it two-layer, the configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and a light-receiving gross area increases it compared with the photo detector of a monotonous mold. This contributes to improvement in the rate of photo electric conversion. There is an advantage which can respond also according to the array of the photo detector CEL5 of the spherule in the above-mentioned configuration even if the shape of surface type of a base material includes the curved surface to some extent.

[0049] Thus, according to the configuration of the light-receiving equipment in each operation gestalt, two or more photo detectors of a spherule are arranged to a base material, and it fixes. Although the photo detector in each operation gestalt is set to about 1mm, even if smaller than it, it does not matter even if large. Thereby, a light-receiving gross area increases compared with the photo detector of a monotonous mold. Moreover, while controlling the reflection of light which carried out incidence, the configuration which can absorb reflection of a light-receiving side further is realizable.

[0050] Moreover, even if the shape of surface type of a base material includes the curved surface to some extent, it can respond. The degree of freedom of the direction of incidence of light becomes larger by this, and it is suitable for solar batteries, such as a car body, head lining of a building, a telegraph pole, a helmet, a transportation device, an electric product, a wrist watch, and a satellite.

[0051]

[Effect of the Invention] As explained above, while controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it according to this invention, the configuration which can absorb reflection of a light-receiving side further can be performed. Consequently, more sunlight can be absorbed from an include angle larger than a monotonous mold, a light-receiving gross area increases, and the light-receiving equipment with which an improvement of the rate of photo electric conversion is realized can be offered.

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TECHNICAL FIELD

[Field of the Invention] This invention relates to the light-receiving equipment applied to the solar battery with which the high rate of photo electric conversion is demanded especially.

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PRIOR ART

[Description of the Prior Art] Energy problems are important on a world-wide scale, and the request and expectation which use sunlight etc. effectively as an energy source just grow. Light-receiving equipments, such as a solar battery and a photodiode, are very useful in it. However, since the consistency of solar energy is low, the power expected for photoelectric conversion efficiency to be low and not to collect sunlight from a big area after all is not obtained.

[0003] Generally, conversion efficiency of a silicon solar cell is theoretically made into about 24%. The present condition is about about ten% of conversion efficiency in fact by whenever [light transmission /, such as reflection of the light of a light-receiving side, a case, and a protective coat,], and recombination of a carrier, the series resistance loss further related to connection, etc.

[0004] Drawing 13 is the type section Fig. showing the configuration of the conventional light-receiving equipments (solar battery etc.). Various ****** besides GaAs and InP explains the ingredient used as a substrate about Si (silicon) here. For example, a diffusion technique etc. is used for the front face of the P type layer 71 which becomes by the P type silicon substrate, and the N type layer 72 is formed. Furthermore, on the N type layer 72, the oxidation silicone film 73 grade is formed as an antireflection film. An electrode 74 is connected to the P type layer 71, and the electrode 75 is connected to the N type layer 72. Two electrodes 74 and 75 are connected with a load 76.

[0005] By the above-mentioned configuration, the light L irradiated by the PN junction generates free charge. That is, by the electric field of the depletion region of the PN-junction section, an electron flows into the N type layer 72, and an electron hole flows into the P type layer 71, respectively. Thereby, the P type layer 71 is just charged in negative, photoelectromotive force produces it in it, and the N type layer 72 can take out a current from two electrodes 74 and 75 for a load 76.

[0006] However, although not illustrated, the light R reflected on N type layer 72 front face, and before reaching a PN junction, light which does not contribute to generating of a current, such as light of the short wavelength which an electron and an electron hole recombine, and light of the long wavelength of only merely penetrating a PN junction, is also considerably.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, while controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it according to this invention, the configuration which can absorb reflection of a light-receiving side further can be performed. Consequently, more sunlight can be absorbed from an include angle larger than a monotonous mold, a light-receiving gross area increases, and the light-receiving equipment with which an improvement of the rate of photo electric conversion is realized can be offered.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Thus, in the former, light-receiving equipment with a flat front face is common in spite of low photoelectric conversion efficiency. In order to most often receive sunlight with low energy density, the gestalt which receives sunlight at right angles to a front face is important. With a monotonous mold, the direction of incidence which can use light effectively is restricted in the semantics.
[0008] This invention is made in consideration of the above-mentioned situation, and the technical problem can absorb more sunlight from an include angle larger than a monotonous mold, and is to offer the light-receiving equipment which realizes an improvement of photoelectric conversion efficiency.

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MEANS

[Means for Solving the Problem] The light-receiving equipment of this invention is characterized by providing the photo detector array object by which the photo detector of the spherule which has a PN junction is electrically connected to two or more [both], and the base material with which said photo detector array object is fixed.
[0010] According to this invention, the configuration in which that a light-receiving gross area increases compared with a monotonous mold with constituting the photo detector array object which consists of a photo detector of two or more spherules also absorbs further reflection of the light which doubled and carried out incidence is realized.
[0011]
[Embodiment of the Invention] Drawing 1 is the external view showing the configuration of the light-receiving equipment concerning the 1st operation gestalt of this invention. the photo detector CEL1 of a spherule arranges in the shape of two or more matrices -- having -- abbreviation -- it is fixed to the flat base material BS 1. The internal P type layer is connected by Electrode TMLp mutually [each adjoining photo detector CEL1 / a surface N type layer is mutually connected by Electrode TMLn, and].
[0012] The matrix array of these photo detectors CEL1 is two-layer like illustration. The matrix array (continuous line) of a two-layer eye is repeated so that the gap GAP during four photo detector sets in the matrix array (broken line) of the 1st layer may be buried. When put, the surface N type layer and the internal P type layer are connected by the 1st layer and the electrodes TMLn and TMLp with which the photo detector of the two-layer eye which contacts was also prepared mutually, respectively. These whole photo detector array is protected by the translucency resin film which is not illustrated.
[0013] Drawing 2 is the sectional view of arbitration showing the example of a configuration for connection 1 unit of photo detector CEL1 in drawing 1 . A photo detector CEL1 is covered with an antireflection film 201, and the translucency metal layer 202 is formed in the bottom of it. As mentioned above, each electrode TMLp is connected with the P type layer 203 of each photo detector CEL1 interior, and each electrode TMLn is connected with the N type layer 204 on the front face of a photo detector, respectively. Each electrodes TMLp and TMLn separate the insulator layers 205, such as an antireflection film and same oxidation silicone film, respectively, and are insulated.
[0014] Only a part to connect with the photo detector which the unit of such electrodes TMLp and TMLn adjoins is prepared in the predetermined part. Namely, the unit configuration of the electrodes TMLp and TMLn of illustration also doubles the connection about the matrix array of a mutually different layer, is the highest per photo detector CEL1, and is 8 unit **********.
[0015] The manufacture process of the photo detector CEL1 of a spherule is performed as follows, for example. While making the polish recon ingredient of the shape of ball-like polish recon material or a thin line which doped impurities of P type, such as boron, impress, fuse and recrystallize an RF generator, it is made to fall in fall tubing which cooled the tube wall, and is made to re-solidify.
[0016] Or a desired height is formed in the silicon single crystal substrate which doped the impurity of P type. To a height, the beam for heating is irradiated and is fused. This builds a melting solid sphere with the big volume with surface tension in a height tip. The root serves as seed crystal and a melting solid sphere carries out recrystallization growth. After predetermined time progress, the root is separated by the laser beam and the melting solid sphere which became large is solidified under the minute gravity in fall tubing etc.
[0017] thus, it was able to do -- doping and a surface layer are mostly formed to the silicon ball front face of a single crystal. That is, the gaseous diffusion of the impurity of N type is carried out, and a PN junction is formed in the predetermined depth from a front face. Next, spatter formation of the translucency metal layer (202) is carried out. Then, antireflection films (201), such as silicon oxide film and

titanic-acid-ized film, are covered. Next, the electrode (TMLp, TMLn) which carries out ohmic contact is separated and formed in the predetermined part on the front face of silicon by insulator layers (205), such as an oxidation silicone film, with the lithography technique using a multi-mirror etc., respectively (refer to drawing 2).

[0018] Soldering is applied in order to connect each of each other's electrodes TMLp and TMLn by adjoining photo detectors. The configurations of each of electrodes TMLp and TMLn are various idea ****. Projection electrodes, such as a solder bump, may be formed.

[0019] Drawing 3 is the general-view Fig. showing the configuration of a part of photo detector in the matrix array periphery of drawing 1 . In each photo detector CEL1 in a matrix array periphery, common connection of each electrode TMLp is made, it is connected with a terminal 11, common connection of each electrode TMLn is made, and it is connected with a terminal 12. For example, it is easy to constitute if the electric conduction pattern connected with terminals 11 and 12 is formed in the seating-rim wall surface of the above-mentioned base material BS 1.

[0020] While controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it according to the above-mentioned configuration, the configuration which can absorb reflection of a light-receiving side further can be performed. That is, as shown in drawing 3 , Light L is absorbed by PN layer from the light-receiving side of a spherule, while the light R in which the remainder was reflected repeats reflection, is absorbed by the light-receiving side and changed into the electrical signal. Thereby, a current can be taken out from the both-ends children 11 and 12.

[0021] By the configuration of the above-mentioned 1st operation gestalt, a light-receiving gross area increases compared with the photo detector of a monotonous mold, and contributes to improvement in the rate of photo electric conversion. It is good also considering the alternative up front face of the photo detector in a lower layer matrix array as a reflecting layer. Moreover, a base material front face may be covered with the reflective film.

[0022] Drawing 4 is the external view showing the advantage of this invention. The array of the photo detector CEL of the spherule in the above-mentioned configuration has the advantage which can respond even if the shape of surface type of a base material BS includes the curved surface to some extent. Thus, a base material may assume all things including the curved surface which is not the circuit board, and can fix and use it with adhesives etc.

[0023] When the matrix array of the photo detector CEL1 shown in the above-mentioned 1st operation gestalt is constituted by the base material including a curved surface, there is concern to which connection of the photo detector between different matrix array layers becomes difficult. In this case, connection of the photo detector between different matrix array layers may be lost. If a path cord is combined as a device of matrix array each of the 1st layer and the 2nd layer, the same terminals 11 and 12 as above-mentioned drawing 3 will be constituted.

[0024] Moreover, although the above-mentioned 1st operation gestalt showed the configuration of a two-layer matrix array, the configuration of only one layer is also considered. According to it, only the part which connects Electrodes TMLp and TMLn with the adjoining photo detector CEL1 is prepared in a predetermined part. By this, the unit which constitutes the group of Electrodes TMLp and TMLn will call it four units per photo detector CEL1. The configuration which can control the reflection of light which carried out incidence also in such a matrix array of one layer, and can be absorbed can be attained, and contributes to improvement in the rate of photo electric conversion. At this time, if base material BS1 front face is covered with the reflective film, in addition, it is good.

[0025] Drawing 5 is the external view showing the configuration of the light-receiving equipment concerning the 2nd operation gestalt of this invention. the photo detector CEL2 of a spherule arranges in the shape of two or more matrices -- having -- abbreviation -- it is fixed to the flat base material BS 2. Concerning each adjoining photo detector CEL2, a surface N type layer is mutually connected by Electrode TMLn about the direction of X of a matrix array, and the internal P type layer is further connected by Electrode TMLp mutually about the direction of Y of a matrix array.

[0026] The matrix array of these photo detectors CEL2 is two-layer like illustration. The matrix array (continuous line) of a two-layer eye is repeated so that the gap GAP during four photo detector sets in the matrix array (broken line) of the 1st layer may be buried. The mutual photo detector CEL2 of the 1st layer and two-layer eye which contact when put has fixed with the transparent adhesives which are not illustrated.

[0027] In each photo detector CEL2 in the above-mentioned matrix array periphery, common connection of each electrode TMLp is made, it is connected with a terminal 21, common connection of each electrode TMLn is made, and it is connected with a terminal 22. For example, it is easy to constitute if the electric conduction pattern connected with terminals 21 and 22 is formed in the seating-rim wall surface of the

above-mentioned base material BS 2.

[0028] Drawing 6 is the sectional view of arbitration showing the example of a configuration of one connection about the photo detector CEL2 in drawing 4 . As mentioned above, Electrode TMLp is connected with the P type layer 203 inside a photo detector, and Electrode TMLn is connected with the N type layer 204 on the front face of a photo detector. These electrodes TMLp and TMLn are formed in the predetermined part, in order to connect with the mutual electrode of the photo detector CEL2 which adjoins the predetermined one direction (the direction of X, or the direction of Y) of a matrix array. Since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL2 of a spherule is omitted. The same sign is given to the same part as said drawing 2 . In addition, the antireflection film formed on the translucency metal layer 202 here is carrying out the illustration abbreviation.

[0029] While controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it also by the configuration of the above-mentioned 2nd operation gestalt, the configuration which can absorb reflection of a light-receiving side further can be performed. It is good also considering the alternative up front face of the photo detector in a lower layer matrix array as a reflecting layer. Thereby, a light-receiving gross area increases compared with the photo detector of a monotonous mold, and contributes to improvement in the rate of photo electric conversion.

[0030] Moreover, there is an advantage which can respond the same with being shown in said drawing 4 even if the shape of surface type of a base material includes the curved surface to some extent. Moreover, although the array of the photo detector CEL2 of a spherule constituted the two-layer matrix array, the configuration of only one layer is also considered. The configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and contributes to improvement in the rate of photo electric conversion. At this time, if a base material front face is covered with the reflective film, in addition, it is good.

[0031] In addition, although the mutual photo detector CEL2 of the 1st layer and two-layer eye which contact with this 2nd operation gestalt when the 1st layer and the matrix array of a two-layer eye are able to be repeated showed the configuration fixed with transparent adhesives Like the 1st operation gestalt, the electrodes TMLp and TMLn prepared, respectively may connect, one one of the electrodes TMLp and TMLn are formed, and a surface N type layer and an internal P type layer may connect each other.

[0032] Drawing 7 is the external view showing the configuration of the light-receiving equipment concerning the 3rd operation gestalt of this invention. On the flat abbreviation base material BS 3 with which the electric conduction pattern was formed, the photo detector CEL3 of a spherule is arranged in the shape of two or more matrices, and is being fixed. A surface N type layer is mutually connected by Electrode TMLn, and, as for each photo detector which adjoins each other about a matrix array, common connection of the internal P type layer is made with Electrode TMLp at the electric conduction pattern on a base material BS 3 (plate PLT).

[0033] The matrix array of these photo detectors CEL3 is two-layer like illustration. The matrix array (continuous line) of a two-layer eye is repeated so that the gap GAP during four photo detector sets in the matrix array (broken line) of the 1st layer may be buried. The P type layer electrode TMLp of each photo detector CEL3 in the matrix array of a two-layer eye is connected common to the electric conduction pattern on a base material BS 3 like the matrix array of the 1st layer by an electrode pin, a wire, etc. through the above-mentioned gap GAP (here, not shown). The whole photo detector array is protected by the translucency resin film which is not illustrated.

[0034] Thus, the each P type layer electrode TMLp in all the photo detectors CEL3 is connected with a terminal 31 through the electric conduction pattern on a base material BS 3 (plate PLT), common connection of the N type layer electrode TMLn of each photo detector CEL3 in one layer and a two-layer matrix array periphery is made, and it is connected with a terminal 32. For example, it is easy to constitute if the electric conduction pattern connected with a terminal 32 is formed in the seating-rim wall surface of the above-mentioned base material BS 3. In addition, since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL2 of a spherule is omitted.

[0035] Drawing 8 is the sectional view of arbitration showing the example of a configuration of the connection about the photo detector CEL3 of drawing 7 . The same sign is given to the same part as said drawing 2 . In addition, the antireflection film formed on the translucency metal layer 202 here is carrying out the illustration abbreviation. As mentioned above, Electrode TMLp is connected with the P type layer 203 inside a photo detector, and Electrode TMLn is connected with the N type layer 204 on the front face of a photo detector. About each matrix array, it adjoins, and electrode TMLn(s) connection is made mutually and common connection of each electrode TMLp is made at the electric conduction pattern (PLT) on a base material BS 3.

[0036] The electric conduction pattern on a base material BS 3 is the conductive thin plate PLT which reflects light like copper, only a connection place is connected with the P type layer electrode TMLp of a photo detector CEL3, and coating of the others is carried out by the translucency resin film FLM. The electrode TMLp of each photo detector CEL3 in the matrix array of a two-layer eye and the electric conduction pattern on a base material BS 3 (plate PLT) are connected by the electrode pin EP.
[0037] While controlling reflection of the light which carried out incidence of the photo detector of a spherule by arranging more than one to a base material, and fixing to it also by the configuration of the above-mentioned 3rd operation gestalt, the configuration which can absorb reflection of a light-receiving side further can be performed. That is, light is absorbed by PN layer from the light-receiving side of a spherule, while the light in which the remainder was reflected also repeats reflection, is absorbed by the light-receiving side and changed into the electrical signal. Consequently, a light-receiving gross area increases compared with the photo detector of a monotonous mold, and contributes to improvement in the rate of photo electric conversion. It is good also considering the alternative up front face of the photo detector in a lower layer matrix array as a reflecting layer.
[0038] Moreover, there is an advantage which can respond the same with being shown in said drawing 3 even if the shape of surface type of a base material includes the curved surface to some extent. Moreover, although the array of the photo detector of a spherule constituted the two-layer matrix array, the configuration of only one layer is also considered. The configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and contributes to improvement in the rate of photo electric conversion.
[0039] Drawing 9 is the external view showing the configuration of the light-receiving equipment concerning the 4th operation gestalt of this invention. two or more photo detectors CEL4 of a spherule are constructed alternately, and constitute a slanting array -- as -- abbreviation -- it is fixed to the flat base material BS 4. The internal P type layer is connected by Electrode TMLp like said 1st operation gestalt mutually [each adjacent photo detector CEL4 / a surface N type layer is mutually connected by Electrode TMLn, and]. Electrodes TMLp and TMLn can be constituted like said 1st operation gestalt. Here, the group (unit) of Electrodes TMLp and TMLn is the highest per photo detector CEL4, and is 6 unit **********.
[0040] In each photo detector CEL4 in the periphery of a slanting array configuration, common connection of each electrode TMLp is made, and common connection of each electrode TMLn is made. For example, it is easy to constitute if the electric conduction pattern of each common path cord is formed in the outer frame wall surface of a base material BS 4. The whole array configuration is protected by the translucency resin which is not illustrated. Since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL4 of a spherule is omitted.
[0041] Drawing 10 is the general-view Fig. showing the important section about the base material BS 4 of drawing 9 . The ****** seating rim touches the honeycomb structure of a base material BS 4 to the periphery of the slanting array configuration of each photo detector CEL4. The common path cord 401 of each electrode TMLp and the common path cord 402 of each electrode TMLn are formed in the wall surface of this seating rim. The common path cord 401 is connected with a terminal 41, and the common path cord 402 is connected with a terminal 42.
[0042] According to the configuration of the above-mentioned 4th operation gestalt, compared with said 1st operation gestalt, the array consistency per one layer of matrix arrays in the photo detector of a spherule can be raised. Although you may make it two-layer, the configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and a light-receiving gross area increases it compared with the photo detector of a monotonous mold. This contributes to improvement in the rate of photo electric conversion. If a base material front face is covered with the reflective film, in addition, it is good. In addition, there is an advantage which can respond even if the shape of surface type of a base material includes the curved surface to some extent also in the above-mentioned configuration.
[0043] Moreover, although illustration is not carried out, as an application as said 2nd operation gestalt explained, it is very good in the configuration which connects electrode TMLp(s) of a photo detector CEL4 to a certain predetermined array direction, and the configuration which connects electrode TMLn(s). Thereby, the total of Electrodes TMLp and TMLn decreases about the photo detector CEL4 per piece.
[0044] Drawing 11 is the external view showing the configuration of the light-receiving equipment concerning the 5th operation gestalt of this invention. On the flat abbreviation base material BS 5 with which the electric conduction pattern was formed, two or more photo detectors CEL5 of a spherule are constructed alternately, and it is fixed so that a slanting array may be constituted. Like said 3rd operation gestalt, a surface N type layer is mutually connected by Electrode TMLn, and, as for each adjacent photo detector CEL5, common connection of the internal P type layer is made with Electrode TMLp at the electric

conduction pattern on a base material BS 5 (plate PLT). The whole array configuration is protected by the translucency resin which is not illustrated.

[0045] The electric conduction pattern on a base material BS 5 is a conductive thin plate (PLT) which reflects light like copper like said 3rd operation gestalt, only a connection place is connected with the P type layer electrode TMLp of each photo detector CEL5, and coating of the others is carried out by the translucency resin film FLM.

[0046] That is, the each P type layer electrode TMLp in all the photo detectors CEL5 is connected with the electric conduction pattern (plate PLT) of base material BS5 pars basilaris ossis occipitalis. Moreover, common connection of each electrode TMLn of each photo detector CEL5 in the periphery of a slanting array configuration is made. For example, it is easy to constitute if the electric conduction pattern of the common path cord of Electrode TMLn is formed in the seating-rim wall surface of the above-mentioned base material BS 5. In addition, since it can carry out like the explanation in said 1st operation gestalt, the manufacture process of the photo detector CEL5 of a spherule is omitted.

[0047] Drawing 12 is the general-view Fig. showing the important section about the base material BS 5 of drawing 11 . The ****** seating rim touches the honeycomb structure of a base material BS 5 to the periphery of the slanting array configuration of each photo detector CEL5. The common path cord 502 of each electrode TMLn is formed in the wall surface of this seating rim. The plate PLT of base material BS5 base is connected with a terminal 51, and the common path cord 502 is connected with a terminal 52.

[0048] According to the configuration of the above-mentioned 5th operation gestalt, compared with said 3rd operation gestalt, the array consistency per one layer of matrix arrays in the photo detector of a spherule can be raised. Although you may make it two-layer, the configuration which can control the reflection of light which carried out incidence at least one layer, and can be absorbed can be attained, and a light-receiving gross area increases it compared with the photo detector of a monotonous mold. This contributes to improvement in the rate of photo electric conversion. There is an advantage which can respond also according to the array of the photo detector CEL5 of the spherule in the above-mentioned configuration even if the shape of surface type of a base material includes the curved surface to some extent.

[0049] Thus, according to the configuration of the light-receiving equipment in each operation gestalt, two or more photo detectors of a spherule are arranged to a base material, and it fixes. Although the photo detector in each operation gestalt is set to about 1mm, even if smaller than it, it does not matter even if large. Thereby, a light-receiving gross area increases compared with the photo detector of a monotonous mold. Moreover, while controlling the reflection of light which carried out incidence, the configuration which can absorb reflection of a light-receiving side further is realizable.

[0050] Moreover, even if the shape of surface type of a base material includes the curved surface to some extent, it can respond. The degree of freedom of the direction of incidence of light becomes larger by this, and it is suitable for solar batteries, such as a car body, head lining of a building, a telegraph pole, a helmet, a transportation device, an electric product, a wrist watch, and a satellite.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the external view showing the configuration of the light-receiving equipment concerning the 1st operation gestalt of this invention.
[Drawing 2] It is the sectional view of arbitration showing the example of a configuration of one connection about the photo detector in drawing 1 .
[Drawing 3] It is the general-view Fig. showing the configuration of a part of photo detector in the matrix array periphery in drawing 1 .
[Drawing 4] It is the external view showing the advantage of this invention.
[Drawing 5] It is the external view showing the configuration of the light-receiving equipment concerning the 2nd operation gestalt of this invention.
[Drawing 6] It is the sectional view of arbitration showing the example of a configuration of one connection about the photo detector in drawing 4 .
[Drawing 7] It is the external view showing the configuration of the light-receiving equipment concerning the 3rd operation gestalt of this invention.
[Drawing 8] It is the sectional view of arbitration showing the example of a configuration of the connection about the photo detector in drawing 7 .
[Drawing 9] It is the external view showing the configuration of the light-receiving equipment concerning the 4th operation gestalt of this invention.
[Drawing 10] It is the general-view Fig. showing the important section about the base material in drawing 9 .
[Drawing 11] It is the external view showing the configuration of the light-receiving equipment concerning the 5th operation gestalt of this invention.
[Drawing 12] It is the general-view Fig. showing the important section about the base material in drawing 11 .
[Drawing 13] It is the type section Fig. showing the configuration of the conventional light-receiving equipments (solar battery etc.).
[Description of Notations]
CEL1-CEL5 -- The photo detector of a spherule, BS1-BS5 -- A base material, TMLp -- The electrode of a P type layer, TMLn -- The electrode of an N type layer, GAP -- A gap, PLT -- A conductive plate, FLM -- The translucency resin film, EP -- An electrode pin, 11, 12, 21, 22, 31, 32, 41, 42, 51, 52 -- Terminal, 71 [-- An electrode, 76 / -- A load, 202 / -- A translucency metal layer, 203 / -- A P type layer, 204 / -- An N type layer, an insulator layer, 401,402,502 / -- A common path cord, L / -- Light R (incident light) / -- Reflected light.] -- A P type layer, 72 -- An N type layer, 73,201 -- 74 An antireflection film, 75

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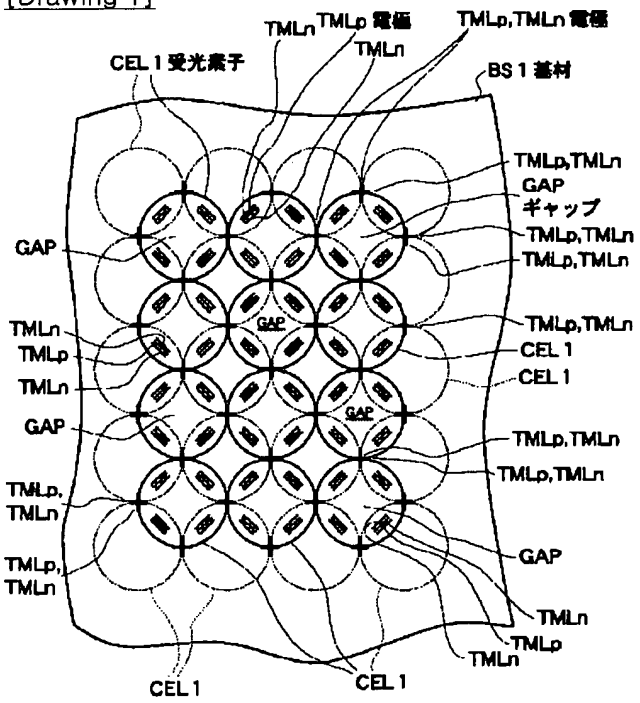
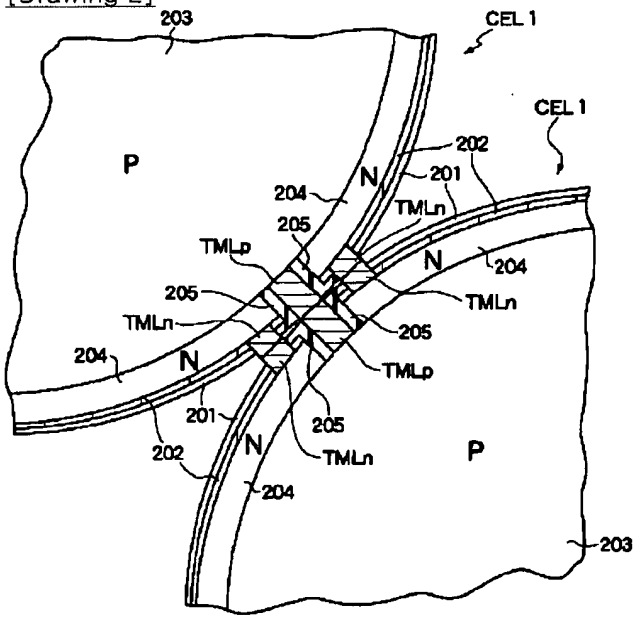
DRAWINGS

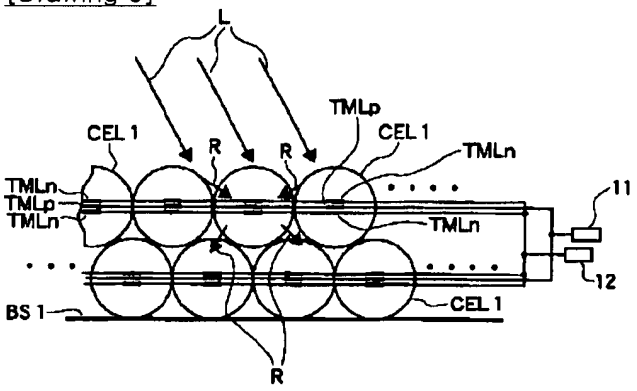
[Drawing 1]



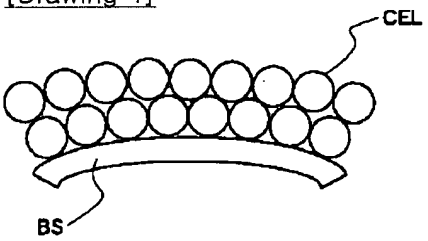
[Drawing 2]



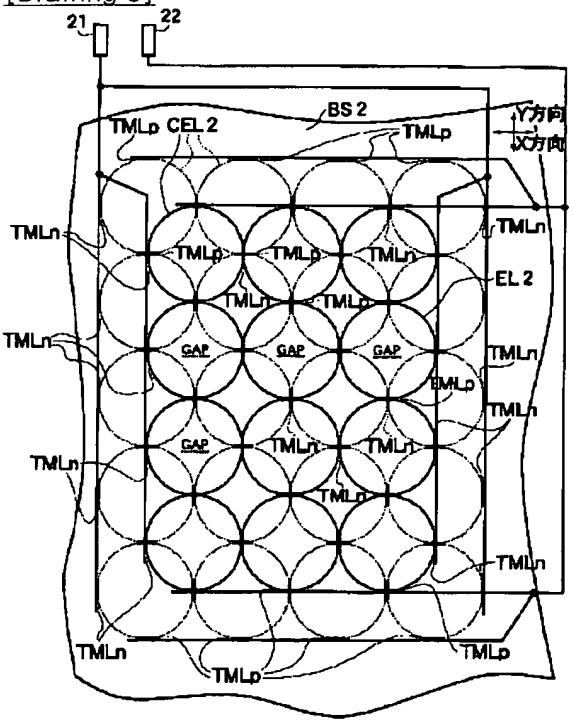
[Drawing 3]



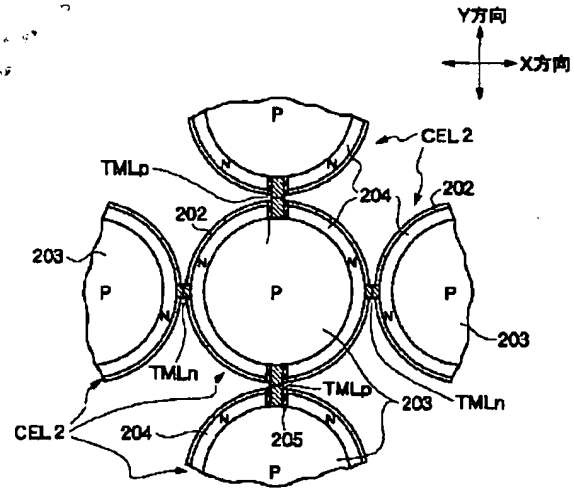
[Drawing 4]



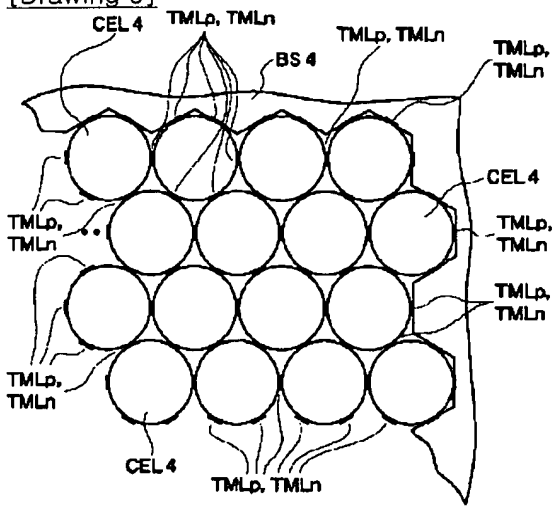
[Drawing 5]



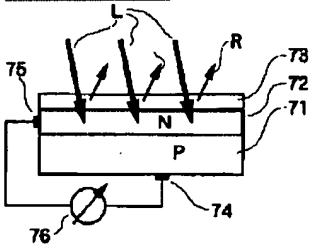
[Drawing 6]



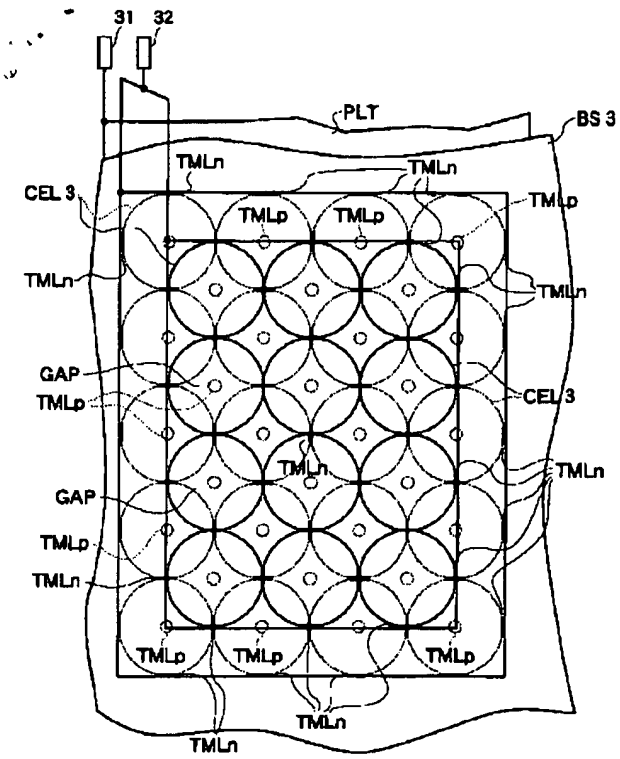
[Drawing 9]



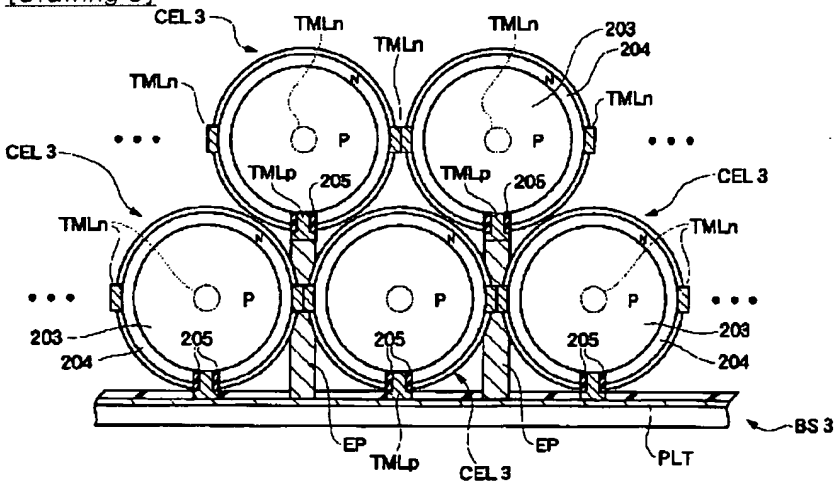
[Drawing 13]



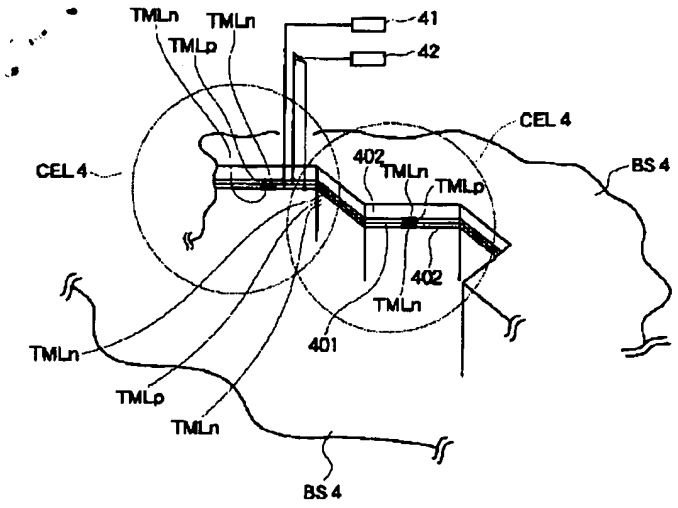
[Drawing 7]



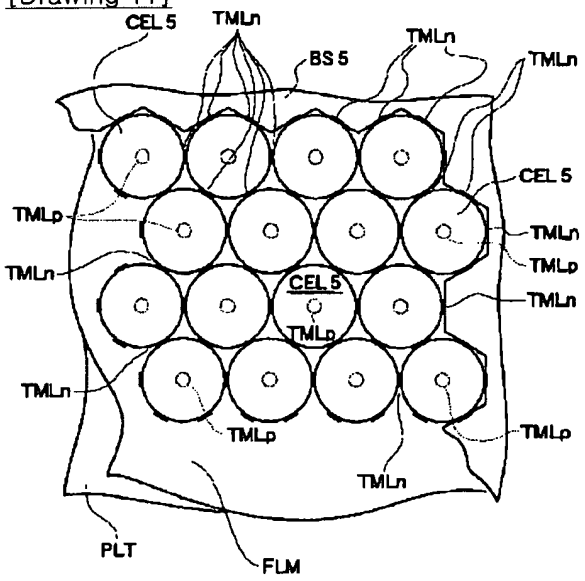
[Drawing 8]



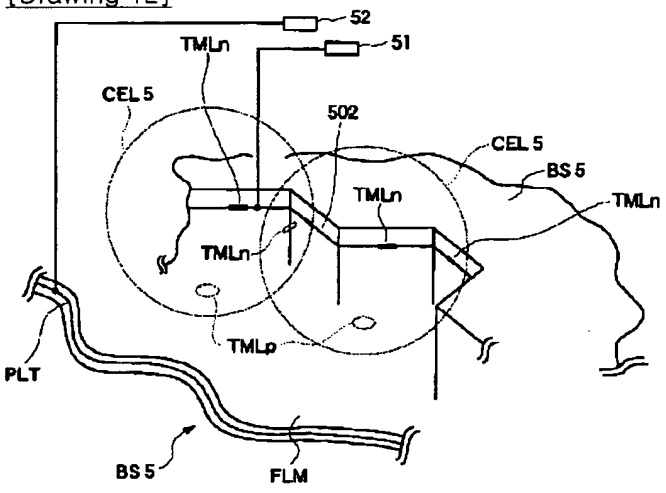
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Translation done.]